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UNITED STATES PATENT APPLICATION

FOR

MULTIPLE MICRO-BLADE REMOVAL DEVICES AND METHODS FOR MANUFACTURING

OF

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MULTIPLE MICRO-BLADE HAIR REMOVAL DEVICES AND METHODS FOR MANUFACTURING

The present invention is directed to devices used for shaving, and more particularly, to hair removal devices comprising a plurality of micro-blades and methods of manufacturing such hair removal devices.

BACKGROUND

Complete hair removal with a shaving device requires that the blades encounter the hair being removed. In attempts to increase the probability of such an encounter, prior art includes devices that conform to body contours and/or have an increased number of cutting surfaces.

For example, US Patent 5,205,040 discloses a shaving cloth wherein a cloth-like or flexible material is used to secure a plurality of individual cutting heads, whereby the cutting heads and their corresponding edges are randomly oriented. When in use the flexible material securing the individual cutting heads contours the body surface.

US Patent 5,088,195 discloses a blade member with multiple cutting surfaces. The blade member is a metal film deformed in

such a way as to form apertures extending above the shave plane. These apertures are subsequently sharpened forming a metal film with a plurality of sharpened apertures. When engaged with the skin, one or more of these sharpened apertures contact one or more hairs and thus cut the hair.

SUMMARY OF THE INVENTION

Various embodiments of the present invention comprise hair removal devices comprising a plurality of micro-blades and methods for their fabrication, including, for example, microelectronic manufacturing techniques. Embodiments of the present invention preferably have many "blades" capable of removing hair. As used herein, the term "blades" is not limited to strips of metal such as stainless steel which are ground and honed to a sharp edge, but includes metals, non-metals, ceramics, semiconductor, and polymeric materials which are preformed and subsequently sharpened or are initially formed with a thickness suitable for cutting hair. The micro-blades can also be formed from multiple layers which have a cumulative thickness suitable for cutting hair or wherein one or more of the layers are subsequently removed leaving a rigid or semi-rigid edge with a thickness suitable for cutting hair. Preferred "blades" of the present invention preferably have at least one edge with a radii of curvature not greater than about

1000 angstroms, preferably not greater than about 500 angstroms, more preferably not greater than about 250 angstroms. Alternative embodiments of the present invention comprise a relatively high number of abrasion elements for hair removal. In addition to blades and/or abrasion elements, shaving devices of the present invention can comprise skin flow control elements which are not designed to cut hair but which serve to control the flow of hair across the shaving device and thereby control the angle at which the blade edges or abrasion elements contact the hair.

Another aspect of the present invention comprises blades having a cutting depth which are much smaller than that of previously known shaving devices. As used herein, the term "cutting depth" is used to indicate the portion of the blade edge which can travel unobstructed through a hair. Since hair typically comprises a diameter of about 75 microns, the cutting depth of previously known shaving elements has been substantially greater than 75 microns to enable the cutting edge to cut entirely through the hair in a single stroke. According to some embodiments of the present invention, the cutting depth of one or more blades is not greater than about 75 microns, or is even less.

According to other aspects of the present invention, shaving devices are formed on rigid or flexible substrates using one or more of the following techniques which include photolithography, wet chemical etching, dry etching such as milling, reactive ion etching, electron cyclotron resonance etching, or sputtering, and deposition techniques such as chemical vapor deposition, sputtering, microwave or radio frequency deposition techniques, or combinations thereof. These manufacturing techniques are described in further detail below. The use of a relatively high number of blades is designed to modify and enhance the efficiency of the shaving process by cutting more hairs more times with each stroke. Instead of a single cut through a hair being shaved, the present invention contemplates cutting each hair with multiple cuts to leave the top of the hair which has been cut with a frayed or dull end rather than a substantially straight and pointed end.

Another aspect of the present invention comprises the use of at least one and preferably a large number of abrasion elements either alone or in combination with micro-blades or skin flow control elements. As used herein, the term "abrasion elements" is used to indicate a structure which by means of action does not cut the hair but uses friction generated by rubbing to erode and break the hair fiber.

Additionally, blades and abrasion elements manufactured using microelectronic manufacturing techniques can be significantly sharper than blades manufactured using standard grinding techniques thus minimizing the effort required to cut each hair. Additionally, since the preferred blades of the present invention are very small relative to known razors, the disclosed devices facilitate shaving in hard to reach places while minimizing discomfort.

According to various embodiments of the present invention, blades can be mounted on blade supports such that they are spaced from the substrate, and can comprise one or more round or straight edges. The blade edges can be scalloped or serrated and can be oriented in one direction or in a plurality of different directions.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a side view of a blade of one embodiment of the present invention.

Figure 2 is a top view of the blade shown in Figure 1.

Figures 3 and 4 are top and side views of a second blade of the present invention.

Figures 5 and 6 are side views and top, perspective views, respectively, of a straight blade of the present invention.

Figures 7 and 8 are top and perspective views, respectively, of an abrasive element of the present invention.

Figures 9 and 10 are side and top views, respectively, of an alternative blade and blade support of the present invention.

Figures 11 and 12 are side and top views, respectively, of another blade of the present invention.

Figures 13 and 14 are side and top views, respectively, of a further embodiment of a blade of the present invention.

Figures 15 and 16 are side and top views, respectively, of a further embodiment of the present invention.

Figures 17 and 18 are side and top views, respectively, of a further embodiment of the present invention.

Figures 19 and 20 are side and top views, respectively, of a further embodiment of the present invention.

Figure 21 is a top view of one embodiment of the present invention showing multiple elements like the ones shown in Figures 1 and 2 arranged.

Figure 22 is a side view of the embodiment illustrated in Figure 21.

Figures 23 and 24 are top and side views, respectively, of an alternative embodiment of the present invention.

Figures 25 and 26 are top and side views, respectively, of an alternative embodiment of the present invention.

Figures 27 and 28 are side and top views of a serrated blade of one embodiment of the present invention.

Figures 29 and 30 are side and top, perspective views, respectively, of another embodiment of the present invention showing an arrangement of multiple elements like those shown in figure 28 which may or may not have serration.

Figures 31 and 32 are side and perspective views, respectively, of another embodiment of the present invention.

Figures 33 and 34 are side and perspective views, respectively, of another blade arrangement of the present invention.

Figures 35 and 36 are top and side views, respectively, of a further embodiment of the present invention showing one possible arrangement of multiple elements like those shown in Figures 3 and 4.

Figures 37 and 38 are top and cross-sectional side views, respectively, of a further embodiment of the present invention.

Figures 39 - 42 illustrate different abrasive elements of embodiments of the present invention.

DETAILED DESCRIPTION

The various embodiments of the present invention comprise novel shaving devices and methods for forming shaving devices. One aspect of the present invention comprises the use of a relatively

large number of micro-blades. As used herein, the term "micro-blades" is used to indicate blades comprising at least one edge having a radii of curvature not greater than about 1000 angstroms, preferably not greater than about 500 angstroms, and more preferable not greater than 250 angstroms, or which comprise a cutting depth of not greater than about 1000 microns. As described in further detail below, hair removal devices of the present invention can comprise hundreds of blades having cutting edges oriented in one or more directions.

One aspect of the present invention comprises the use of micro-blades, preferably a high number of micro-blades, either alone or in combination with other skin engaging elements and/or abrasive elements. Figures 1 and 2 are side and top views, respectively, of one micro-blade unit 10 which comprises a blade support 12, a blade 14 having a cutting edge 15 and a cutting edge support 16. The various illustrations shown herein are intended to be illustrative of portions of shaving devices and not entire shaving devices of the present invention. This illustrated blade 14 and blade edge 15 are extremely thin and therefore are capable of cutting hair when drawn across a skin surface in any direction. The bottom of blade support 12 is preferably formed from a substrate (shown in phantom) which is most preferably flexible.

The blade support 12 is preferably about 10 to 1000 microns high in order to elevate blade 14 at least about 10 microns from the substrate. Cutting edge 15 of blade 14 has a radius of curvature not greater than about 1000 angstroms, preferably not greater than 500 angstroms, more preferably not greater than about 250 angstroms, still more preferably not greater than about 100 angstroms. The most preferred embodiments of the present invention have cutting edges with radii of curvature not greater than about 50 angstroms. The preferred micro-blades of the present invention have radii of curvature which are significantly sharper than conventional stainless steel blades which are typically honed and sharpened to a radii of curvature of about 500 angstroms.

The micro-blade illustrated in Figures 1 and 2 also comprises a cutting depth **D** which can be significantly less than the cutting depths of conventional blades. The cutting depths of some micro-blades of the present invention are preferably not greater than about 1000 microns, more preferably, not greater than about 500 microns, still more preferably, not greater than about 250 microns, not greater than about 100 microns, not greater than about 75 microns and most preferably not greater than about 50 microns. While this and some other illustrated embodiments comprise cutting depths of less than about 1000 microns, advantages of the present

invention can be achieved with much greater cutting depths. The use of these relatively small cutting depths is one aspect of the present invention and is not necessary for all embodiments.

The shape of the micro-blade shown in Figures 1 and 2 is round. The micro-blades of the present invention are not limited to any specific shape and can have, for example, curved or straight surfaces. For example, the present invention can also be practiced using micro-blades which are hexagonal, triangular, rectangular, or any other geometric shape desired.

A plurality of structures such as those shown in Figures 1 and 2 can be arranged in various patterns, such as, but not limited to that shown in Figures 21 and 22. The micro-blade structures are preferably generated simultaneously using standard microelectronic manufacturing techniques. One possible sequence of steps to form such structures includes starting with a substrate made of polyimide, polyetheretherketone (PEEK), other flexible materials alone or in combination, with a thickness of about 0.05 mm to 2 mm, preferably with a thickness of about 0.1 mm to 0.5 mm. A thin film of tungsten, tantalum nitride, boron nitride, diamond, or any other desired blade material is subsequently deposited onto the substrate. The desired film thickness is dependent on the blade

material strength such that the buckling force of the blade film exceeds the maximum force required to cut a hair. A material whose thickness meets the above criteria and is 1000 angstroms or less is most desirable. The deposition of blade materials can include one or more deposition techniques standard in the manufacturing of microelectronics and integrated circuits including, but not limited to, chemical vapor deposition, plasma assisted chemical vapor deposition, electron cyclotron resonance deposition, sputter deposition, and radio frequency assisted deposition techniques. One or more support materials such as chromium, aluminum, tungsten, or any other desired support material can also be deposited on top of the blade material to enhance the structure's stability and durability. To form the structures, the film stack comprising the substrate and deposited films is patterned using photolithography techniques and the deposited films as well as the substrate are selectively etched with one or more etching techniques. The etching techniques which are useful with the present invention include, but are not limited to, sputtering, reactive ion etching, and electron cyclotron resonance etching, and wet chemical etching.

Figures 9 and 10 illustrate a micro-blade unit of the present invention. This embodiment is similar to the embodiment illustrated in Figures 1 and 2; however, support element 16 shown

in Figure 1 has been eliminated and the blade edge has been formed by etching a thick film leaving an angular cutting edge 55. Etching of the blade edge can be accomplished using either wet or dry etching techniques. In this embodiment, the support element is not required due to the overall thickness of the blade element 54 whose material strength well exceeds the force required to cut a hair.

Figures 3 and 4 illustrate an alternative micro-blade unit 20 of the present invention wherein an aperture is provided internally of the sharpened cutting edge 25 of blades 24. These micro-blades comprise a base 22 which is formed on a substrate 21 by film deposition techniques. These micro-blade units 20 will only cut hair which is forced into the aperture defined by circular blade edge 25.

The shape of the micro structures shown in Figures 3 and 4 is round; however, those who are knowledgeable in the art would realize this is only one of many shapes one could generate. Micro structure shapes may include but are not limited to hexagonal, triangular, rectangular, or any other geometric shape.

A plurality of structures such as those shown in Figures 3 and 4 and arranged in a pattern such as, but not limited to, that shown in Figures 35 and 36 are generated simultaneously using standard microelectronic manufacturing techniques. One possible sequence of steps to form such structures include starting with a substrate made of polyimide, polyetheretherketone (PEEK), other flexible material or combinations thereof with a thickness ranging of about 0.05 mm to 2 mm, preferably with a thickness range of about 0.1 mm to 0.5 mm. Substrates are subsequently patterned with photoresist resulting in structures of a desirable shape, for example hollow cylindrical blade support structures, arranged on the substrate in the desired pattern. The height of the cylindrical blade support structures is preferably about 10 to 1000 microns, preferably greater than 100 microns. One or more films are deposited onto the substrate and cover the photoresist structures. The deposited films can consist of tungsten, tantalum nitride, boron nitride, diamond, or any other desired blade material. The desired film thickness range is about 1 micron to 5 microns, preferably with a thickness range of about 2 microns to 4 microns. Photolithography techniques are implemented again to form the blade edge 25 by exposing the metal film in the center of each cylindrical structure. The blade is formed by either dry etch or wet etch techniques. Once blade edge 25 is formed, the photoresist which makes up the cylinder

structure is removed using appropriate dry etch or wet etch techniques leaving the blade structure as illustrated in Figures 3 and 4.

Figures 5 and 6 illustrate a substantially linear micro-blade of another embodiment of the present invention. Figure 5 is a side view illustrating blade 30 having a cutting edge 35 extending from a substrate (shown in phantom) at an angle. Figure 6 illustrates the cutting edge 35 of this linear blade. The blades in this embodiment of the present invention can be oriented in the same or different directions as they extend upwardly at some angle relative to the substrate.

A plurality of structures such as those shown in Figures 5 and 6 and arranged in a pattern such as, but not limited to, that shown in Figures 29 and 30 are generated simultaneously using standard microelectronic manufacturing techniques. One possible sequence of steps to form such structures includes starting with a substrate made of polyimide, polyetheretherketone (PEEK), or other flexible material with a thickness ranging from 0.05 mm to 2 mm, preferably with a thickness range of 0.1 mm to 0.5 mm. One or more films are deposited onto the substrate. The deposited films can consist of tungsten, tantalum nitride, boron nitride, diamond, or any other

desired blade material. The desired film thickness is about 10 microns to 1000 microns, preferably with a thickness range of about 100 microns to 300 microns. To form the structures, the film stack consisting of the substrate and deposited films is patterned using photolithography techniques. The deposited films as well as the substrate are subsequently selectively etched, preferably with the substrate angled with respect to the etch source, with techniques that include but are not limited to ion milling, sputtering, reactive ion etching, and electron cyclotron resonance etching.

Figures 7 and 8 illustrate an abrasive element of one embodiment of the present invention having a generally pyramidal shape. Figure 7 is a top view showing four generally triangular sides 41-44. Figure 8 is a perspective view. This illustrated abrasive element and other abrasive elements of the present invention are preferably formed of hard materials, such as those described above for forming blades and function like sandpaper to abrade the hair away leaving the edges of hair frayed and resulting in a smooth feel. The abrasive elements of the present invention can take different forms such as those shown in Figures 39 through 42.

A plurality of structures such as those shown in Figures 7, 8, and 39 through 42 can be arranged in a pattern and generated simultaneously using standard microelectronic manufacturing techniques. One possible sequence of steps to form such structures includes starting with a substrate made of polyimide, polyetheretherketone (PEEK), or other flexible material with a thickness ranging from 0.05 mm to 2 mm, preferably with a thickness range of 0.1 mm to 0.5 mm. One or more films are deposited onto the substrate. The deposited films can consist of tungsten, tantalum nitride, boron nitride, diamond, or any other desired abrasive material. The desired film thickness is about 2 microns to 55 microns, preferably with a thickness of about 20 microns to 30 microns. To form the structures, the film stack consisting of the substrate and deposited films is patterned using photolithography techniques and the deposited films are selectively etched with techniques that include but are not limited to ion milling, sputtering, reactive ion etching, and electron cyclotron resonance etching. Although it may be preferred for the abrasive elements to exhibit a sharper peak at the top of the structure, current microelectronic manufacturing techniques known to the present inventors do not make the formation of such a structure possible. Advantages are also gained by not having a sharp peak on

top of the abrasive structures by limiting the incidence of skin abrasion.

Figures 11 and 12 illustrate a further embodiment of the present invention wherein the blade edge of a micro-blade unit similar to those shown in Figures 1, 2, 9 and 10 comprises a plurality of segments. Although Figures 11 and 12 show an eight-pointed star-shaped blade when viewed from above, there can be any number of segments by a blade structure without departing from the scope of the present invention. While this illustrated embodiment shows substantially linear sharpened edges, the edges can also be curved, scalloped or serrated having a plurality of curved, cutting edges.

Figures 13 through 16 illustrate two additional embodiments of the present invention wherein generally circular micro-blades have two circular cutting edges, a first formed internally and a second formed externally. The embodiments shown in Figures 13 and 14 comprise thin film edges 75 and 76 supported by a donut shaped blade support 72. An upper blade support 77 helps to maintain the blade on blade support 72. The embodiment illustrated in Figures 15 and 16 comprises etched external edges 85 and internal edges 86 mounted on a blade support 82. These double edged micro-blade

units advantageously provide cutting action when drawn in any direction across a skin surface being shaved. Although not shown, these edges can be serrated, scalloped or shaped.

Two additional embodiments of the present invention are shown in Figures 17 through 20. These embodiments comprise only internal cutting edges. The embodiments shown in Figures 17 and 18 comprise a single thin film edge 96 located interiorly of the blade and the embodiment illustrated in Figures 19 and 20 comprises an etched interior edge 106. Although not shown, these edges can also be serrated, scalloped or shaped.

The micro-blades, abrasive elements, and/or non-cutting, non-abrasive skin engaging elements of the present invention can be positioned in any manner desired on a substrate. Figures 21 and 22 illustrate micro-blades of the type illustrated in Figures 1 and 2 positioned in slightly offset rows on a flexible substrate 110. These blade units are positioned in spaced arrangement. Blade unit spacing is preferably about 75 microns to 1500 microns with a more preferred range of about 200 microns to 800 microns. Figures 23 and 24 are top and side views of an alternative embodiment of the present invention wherein blade units are surrounded by a non-

cutting structure 18 in order to direct and enhance skin flow during hair removal.

As stated above, one or more skin engaging elements which are not designed to abrade or cut hair can also be positioned around, between, or amongst micro-blades or abrasive elements of the present invention. These skin engaging elements provide a function similar to a conventional guard bar in that they are designed to stretch the skin and/or optimize the flow of skin and hair toward one or more cutting edges. Additionally, they can provide support by restricting a flexible blade from collapsing into another skin engaging element, by improving the hair capturing capability of the sharpened blade edge and/or by providing desirable tactile sensations during hair removal.

Figures 25 and 26 are top and side views, respectively, of an embodiment of the present invention comprising truncated skin engaging elements 135 which are positioned in rows between micro-blade units 10. The skin engaging elements of the present invention are preferably formed of a resilient material, such as those materials described above which can be used to form a flexible substrate. The skin engaging elements can be used with micro-blades, with abrasion element such as those shown in Figures

7 and 39 to 42, or with both micro-blades and abrasive elements. In order to facilitate manufacture, the skin engaging elements 135 can be identical to the blade supports 12 but are not provided with an actual blade. While this illustrated embodiment shows offset rows of micro-blade units 10 and skin engaging elements 135, the arrangement of the blades and skin engaging elements can be staggered and need not form rows.

Figures 27 and 28 show an embodiment of the present invention similar to that shown in Figures 5 and 6, however, the cutting edge 145 of each blade is serrated, instead of linear.

Figures 29 and 30 show one method of arranging a plurality of linear micro-blades 30 having cutting edges 35 of one embodiment of the present invention on a substrate 150. In this embodiment, the blade edge directions are aligned and faced in a single direction. In the embodiment shown in Figures 31 and 32, the blade edges are crossed having one set of blades facing one direction and another set of blades facing another.

The embodiment shown in Figures 33 and 34 shows alternating blade edges facing into different directions. From the present description it will also be appreciated by those skilled in the art

that these or other micro-blades can be angled in one, two or even more directions to provide multi-directional shaving action.

Figures 37 and 38 are top and cross-sectional side views, respectively, of another embodiment of micro-blades of the present invention. These illustrated micro-blades are mounted on a substrate 180 and comprise micro-blade supports 185 upon which are deposited micro-blade edges 186 and upper blade supports 188. The upper blade supports 188 are designed to provide greater support to the micro-blade edges 186. During the deposition of upper blade supports 188, some of the upper blade support material 189 may enter the interior portion of blade support 185 if that region is not covered during the deposition of this upper blade support material. In accordance with this and other embodiments of the present invention, upper blade support material 188 can also be used to provide a degree of skin flow control if desired.

The various embodiments of the present invention are preferably formed by manufacturing techniques which have been previously known in the area of microelectronics such as integrated circuits and printed circuit boards. These manufacturing techniques are capable of providing significantly sharper cutting edges than the blades manufactured using standard grinding and

honing techniques. It is believed that these blades will minimize the effort required to cut each hair.

Such techniques can include photolithography for patterning, dry plasma and wet chemical etches for material removal and plasma depositions for material application.

The substrates of the present invention can generally be in the form of a towelette or can be formed as a razor head on a permanent handle or on a disposable handle. As used herein, the term "razor head" is meant to include cartridges adapted to be connected to a separate razor as well as the operative cutting portion of a disposable razor wherein the handle and cutting portion are formed as a single unit. The substrates of the present invention can be flexible or rigid. The techniques of the present invention can be utilized to provide many blades, abrasive elements and skin engaging elements. For example, according to the present invention, hair removal device can comprise at least ten, fifty, one hundred, two hundred, five hundred or even at least about one thousand micro-blades.

One particular type of substrate may comprise a polyimide. The blades can be arranged on the substrate, randomly, in staggered

rows, in ordered rows and columns or in any other desired arrangement.